IN THE CLAIMS:

1. In a bi-directional data transmission system that facilitates communications between a central unit and a plurality of remote units using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete subchannels including an overhead bus having a plurality of overhead subchannels, a method of synchronizing frames transmitted from a selected remote unit to the central unit, the method comprising the steps of:

(a) when the selected first remote unit desires to establish communications with the central unit, receiving a first signal from the central unit and loop timing a clock at the selected first remote unit with a clock signal carried in the first signal;

(b) transmitting a remote initiated synchronization signal from the loop timed selected first remote unit to the central unit over an overhead subchannel in the overhead bus when the selected first remote unit desires to establish communications with the central unit;

(c) transmitting a centrally initiated synchronization signal from the central unit to the selected first remote unit when the central unit receives the remote initiated synchronization signal, wherein the centrally initiated synchronization signal contains information indicative of a frame boundary phase shift required to better synchronize the selected first remote unit with other remote units that are currently communicating with the central unit; and

(d) shifting the phase of the frames outputted by the selected first remote unit in response to the centrally initiated synchronization signal to better synchronize the frame boundaries of the frames outputted by the selected first remote unit with frame boundaries of frames output by the other remote units that are currently communicating with the central unit;

whereby the synchronization is arranged such that when fully synchronized, the frame boundaries from the various remotes will substantially coincide when they are received at the central unit.

2. A method as recited in claim 1 wherein the overhead bus includes two dedicated overhead subchannels, and the remote initiated synchronization signal and the centrally initiated synchronization signal are transmitted over different overhead subchannels.

3. A method as recited in claim 1 wherein a single dedicated overhead subchannel is provided, and the remote initiated synchronization signal and the centrally initiated synchronization signal are both transmitted over the single dedicated overhead subchannel.

4. A method as recited in claim 1 wherein when two of the remote units transmit their associated remote initiated synchronization signals at substantially the same time, a

conflict is recognized and the remotes units each resend an associated remote initiated synchronization signal.

5. A method as recited in claim 1 wherein steps b, c and d are repeated until the selected remote unit is fully synchronized and further comprising the step of initiating normal communications from the selected remote unit to the central unit.

6. A discrete multi-carrier central modem unit for use in a bi-directional data transmission system that facilitates communications between the central modem unit and a plurality of remote modem units, the central modem unit comprising:

an encoder for encoding digital information;

a monitor for monitoring a communication line to determine line quality parameters indicative of noise levels at each of a multiplicity of subchannels, each subchannel corresponding in frequency to an associated subcarrier;

a modulator for modulating the encoded digital information onto a multiplicity of subcarriers in a frame based discrete multi-tone signal, each subcarrier corresponding to an associated tone and an associated subchannel, the modulation being arranged to take into consideration at least the detected line quality parameters and a permissible power mask parameter, and wherein the modulation is capable of dynamically updating both the subchannels used and the amount of data transmitted on each subchannel during transmission in order to accommodate real time changes in specific parameters;

an apparatus for appending a cyclic prefix to the discrete multi-tone signal before it is applied to the transmission line; and

a synchronizer for monitoring signals received over a dedicated overhead subchannel, identifying a remote initiated synchronization signal that is received on the overhead subchannel, determining the phase shift between a frame boundary of the remote initiated synchronization signal and a frame boundary of a frame in said discrete multi-tone signal and generating a centrally initiated synchronization signal for transmission to the remote modem units that is indicative of a frame boundary phase shift required to synchronize a selected remote modem that initiated the remote initiated synchronization signal with other remote units that are currently communicating with the central modem unit.

7. A discrete multi-carrier remote modem unit for use in a bi-directional data transmission system that facilitates communications between a central modem unit and a plurality of said remote modem units, the remote modem unit comprising:

a demodulator for demodulating a first discrete multi-tone signal indicative of a first set of digital information, the demodulator being arranged to receive modulation information as part of the discrete multi-tone signal, wherein the demodulator is capable

of dynamic updating during reception in response to changed modulation information in order to accommodate real time changes in the modulation scheme, the demodulator being arranged to strip a cyclic prefix from the discrete multi-tone signal;

a decoder for decoding the demodulated digital information in real time;

an encoder for encoding a second set of digital information;

a modulator for modulating the encoded second set of digital information onto a multiplicity of subcarriers in a second discrete multi-tone signal, each subcarrier in the second discrete multi-tone signal corresponding to an associated tone and an associated subchannel; and

a synchronizer for generating a first synchronization signal that is applied to an overhead subcarrier when the discrete multi-tone remote modem desires to initiate communications to the central modem, receiving a second synchronization signal from the central modem that is indicative of a frame boundary phase shift required to synchronize the remote modem with other remote units that are currently communicating with the central modem unit, and shifting the phase of the second discrete multi-tone signal so that it is synchronized at the central modem with multi-tone signals sent by said other remote units.

8. A remote modem unit as recited in claim 7 wherein the demodulator further includes a time domain equalizer.

9. A remote modem unit as recited in claim 7 wherein the demodulator and the decoder are part of a receiver, and the remote unit further comprises an analog notch filter arranged to filter the first discrete multi-tone signal before it is passed to the receiver to reduce the energy level of the signals handled by the receiver.

10. In a bi-directional data transmission system that facilitates communications between a central unit and a plurality of remote units using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete subchannels including an overhead bus, a method of synchronizing frames transmitted from a selected remote unit to the central unit, the method comprising the steps of:

when the selected first remote unit desires to establish communications with the central unit, receiving a first signal from the central unit and loop timing a clock at the selected first remote unit with a clock signal carried in the first signal;

transmitting a remote initiated synchronization signal from the selected first remote unit to the central unit over a dedicated overhead subchannel in the overhead bus when the clock is loop timed with the clock signal in the first signal;

receiving a centrally initiated synchronization signal transmitted from the central unit in response to the remote initiated synchronization signal, wherein the centrally

initiated synchronization signal contains information indicative of a frame boundary phase shift required to synchronize the selected first remote unit with other remote units that are currently communicating with the central unit; and

shifting the phase of the frames outputted by the selected first remote unit in response to the centrally initiated synchronization signal to better synchronize the frame boundaries of the frames outputted by the selected first remote unit with frame boundaries of frames output by the other remote units that are currently communicating with the central unit, the synchronization being arranged to occur such that the frame boundaries from the various remotes are arranged to substantially coincide when they are received at the central unit.

11. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit and using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels for facilitating upstream communications between the plurality of remote units and the central unit, a method of synchronizing frames transmitted from a selected first remote unit to the central unit with frames transmitted from other remote units to the central unit, such that frame boundaries of the frames transmitted from the first remote unit arrive at the central unit substantially in synchrony with frames boundaries of frames transmitted from the other remote units, the method comprising the steps of:

periodically providing synchronized quiet times on the plurality of discrete sub-channels provided for facilitating upstream communications; and

transmitting a broad band initialization signal from the first remote unit to the central unit during a first selected synchronized quiet time, the broad band initialization signal including a plurality of initialization signals transmitted over distinct sub-channels, the broad band initialization signal having frame boundary.

12. A method as recited in claim 11 wherein:

when the first remote unit desires to establish communications with the central unit, said first remote unit monitors downstream communication broadcast by the central unit and substantially synchronizes the frame boundary of the broad band initialization signal with a frame timing marker carried in downstream signals received by the remote unit;

the central unit receives the broad band initialization signal and sends a synchronization signal to the first remote unit, the synchronization signal having information indicative of a frame boundary shift required to better synchronize frame boundaries of signals sent by the first remote unit with frame boundaries of signals sent by other remote units that are communicating with the central unit; and

shifting the boundary of the frames outputted by the first remote unit in response to the synchronization signal to better synchronize the frame boundaries of the frames outputted by the first remote unit with the frame boundaries of frames output by the other remote units that are currently communicating with the central unit; and

whereby the synchronization is arranged such that when fully synchronized, the frame boundaries from the various remotes will substantially coincide when they are received at the central unit.

13. A method as recited in claim 11 or 12 further comprising the step of periodically providing synchronized training times on the plurality of discrete sub-channels provided for facilitating upstream communications, wherein remote units that are not requested to train or retrain during a particular training time are quiet during that particular training time.

14. A method as recited in claim 13 further comprising the step of causing the first remote unit to send a plurality of training signals over a number of the sub-channels provided for facilitating upstream communications during a selected training time.

15. A method as recited in claim 14 further comprising the step of determining a first set of channel characteristics indicative of the channel capacities of the multiplicity of sub-channels provided for facilitating upstream communications.

16. A method as recited in claim 15 further comprising the step of saving the first set of channel characteristics within a matrix of channel characteristics, wherein said matrix contains information indicative of the channel capacities of the multiplicity of discrete sub-channels between all the remote units and the central unit.

17. A method as recited any one of claims 11-16 further comprising the steps of:

recognizing a conflict when more than one of said remote units transmits an associated broad band initialization signal during the first selected synchronization time;

transmitting a conflict signal to the plurality of remote units in response to the broad band initialization signals when a conflict is recognized; and

wherein each of the conflicting remote units resends its broad band initialization signal during a later one of said synchronized quiet times, the conflicting remote units being arranged to each wait an independently random interval prior to resending its broad band initialization signal.

18. A method as recited in any one of claims 11-17 wherein the synchronized quiet time has a period that is sufficiently long such a quiet period marker transmitted from the

central unit may be transmitted to the remote unit that is furthest from the central unit and an initialization signal that is responsive to the quiet period marker returned to the central unit all within the synchronized quiet time.

19. A method as recited in claim 18 wherein the synchronized quiet time has a period in the range of approximately 50 to 500 milliseconds.

20. A method as recited in claim 11-19 further comprising the step of periodically transmitting from the central unit an indication of sub-channels that are forbidden from use by the remote unit, wherein the remote unit makes sure that the broad band initialization signal does not include any transmissions in the sub-channels that are forbidden from use.

21. A method as recited in claim 12 wherein the downstream communications are discrete multi-tone signals and the frame timing marker carried in the downstream signals received by the remote unit are frame boundaries of the downstream discrete multi-tone signals.

22. A method as recited in claim 12 wherein the downstream communications are selected from the group consisting of quadrature amplitude modulated signals and vesigial sideband signals.

23. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, a method of dynamically checking sub-carrier transmission quality from the remote units to the central unit to facilitate the allocation of bandwidth to the remote units by the central unit, the method comprising the steps of:

(a) periodically providing synchronized quiet times on the plurality of discrete sub-channels provided for facilitating upstream communications, wherein remote units that are not requested to train or retrain during a particular training time are quiet during that particular training time;

(b) transmitting training signals from a first one of the remote units over the multiplicity of sub-channels provided for facilitating upstream communications during a selected synchronized quiet time; and

(c) monitoring the training signals transmitted during the selected training time at the central unit and determining a first set of channel characteristics indicative of the

capacities of the multiplicity of sub-channels provided for facilitating upstream communications,

whereby the central unit may use the first set of channel characteristics when determining which sub-channels to allocate to the selected first remote unit for upstream communications.

24. A method as recited in claim 23 further comprising the step of saving the first set of channel characteristics within a matrix of channel characteristics, wherein said matrix contains information indicative of the channel capacities of the multiplicity of discrete sub-channels between all the remote units and the central unit.

25. A method as recited in claim 24 further comprising the step of adjusting the set of sub-channels allocated to the selected first remote unit based upon a set of information derived from the plurality of training signals transmitted to the central unit.

26. A method as recited in any one of claims 23-25 further comprising the step of repeating the transmitting and monitoring steps for a plurality of different remote units in order to determine channel characteristics for each of the plurality of different remote units to facilitate the dynamic allocation of bandwidth to various remote units, wherein different remote units transmit their respective training signals during different quiet times.

27. A method as recited in claim 23-26 further comprising the step of sending a retraining signal to the selected first remote unit, wherein the selected first remote unit only transmits its training signals in response to the reception of a retraining signal.

28. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, a method of dynamically checking sub-carrier transmission quality from the remote units to the central unit to facilitate the allocation of bandwidth to the remote units by the central unit, the method comprising the steps of:

(a) periodically providing synchronized quiet times on the plurality of discrete sub-channels provided for facilitating upstream communications, wherein remote units that are not requested to train or retrain during a particular training time are quiet during that particular training time;

(b) sending a retraining signal to a selected first one of remote units;

(c) transmitting training signals from the selected first remote units to the central unit over the multiplicity of sub-channels provided for facilitating upstream communications during a selected synchronized quiet time, wherein the selected first remote unit only transmits its training signals in response to the reception of a retraining signal; and

(d) monitoring the training signals transmitted during the selected training time at the central unit and determining a first set of channel characteristics indicative of the capacities of the multiplicity of sub-channels provided for facilitating upstream communications;

(e) saving the first set of channel characteristics within a matrix of channel characteristics, wherein said matrix contains information indicative of the channel capacities of the multiplicity of discrete sub-channels between the various remote units and the central unit, whereby the central unit may use the matrix of channel characteristics when determining which sub-channels to allocate to the various first remote unit for upstream communications; and

(f) repeating the sending, transmitting, monitoring and saving steps for additional remote units, wherein different remote units transmit their respective training signals during different quiet times.

29. A method as recited in claim 28 further comprising the step of determining if there is a remote unit requesting an immediate updating and if there is such a remote unit, sending the next retraining signal to the requesting remote unit.

30. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, a method of informing the central unit of the transmission requirements of a remote unit, the method comprising the steps of:

periodically providing synchronized quiet times on the plurality of discrete sub-channels provided for facilitating upstream communications, wherein remote units that are not authorized to transmit data request information during a particular quiet time are quiet during that particular quiet time;

transmitting a data transmission request signal from a selected first remote to the central unit at a time other than during a quiet time interval;

transmitting an authorization signal to the selected first remote unit allocating a first quiet time to the selected first remote unit;

transmitting data request information from the selected first remote to the central unit over a plurality of the discrete sub-channels during the first quiet time; and

allocating at least one sub-channel to the selected first remote unit in response to the data request information for facilitating upstream communications between the first remote unit and the central unit.

31. A method as recited in 30 wherein the data transmission request signal is a data rate request signal, and wherein the central unit allocates sufficient sub-channels to the selected first remote unit such that the selected first remote unit can transmit at a requested data rate that is specified in the data request information.

32. A method as recited in claim 31 wherein the central unit allocates sufficient sub-channels to the selected first remote until the selected first remote unit indicates that it desires a change.

33. A method as recited in any one of claims 30-32 wherein the data transmission request signal is a data packet request signal, and wherein the central unit allocates the at least one sub-channel to the selected first remote unit for an amount of time sufficient to transmit an amount information that is specified in the data request information.

34. A method as recited in any one of claims 30-32 wherein defined data packet information is included in the data request information, the method further comprising the step of transmitting a defined data packet request signal from the selected first remote unit to the central unit after the defined data request information has been transmitted, wherein the central unit allocates at least one sub-channel to the selected first remote unit in direct response to the defined data packet request.

35. A method as recited in any one of claim 30-34 wherein the first remote unit monitors communications prior to transmitting the data request signal and transmits the data request signal only over at least one sub-channel that is not in use.

36. A method as recited in claim 30 wherein a first value of the data transmission request signal is indicative of a data rate request, a second value of the data transmission request signal is indicative of a data packet request and a third value of the data transmission request signal is indicative of a defined data packet request.

37. A method as recited in claim 36 wherein the data transmission request signal is a two bit signal.

38. A method as recited in claim 30 wherein a first value of the data transmission request signal is indicative of a request for allocation of a quiet period and a second value of the data transmission request signal is indicative of a defined data packet request.

39. A method as recited in any one of claims 30-38 wherein the discrete multi-carrier transmissions are divided into frames, with each frame including a multiplicity of symbols and wherein each remote unit is assigned an associated symbol during which it may transmit its data request symbol and wherein the central unit determines the identity of a particular remote unit transmitting a data transmission request signal based at least in part upon the symbol during which the data transmission request signal is received.

40. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, a method of informing the central unit of the transmission requirements of a remote unit, the method comprising the steps of:

transmitting a data transmission request signal from a selected first remote to the central unit during a particular symbol in a data frame that is associated with the selected first remote unit on at least one sub-channel that are not otherwise in use by any of the remote units;

transmitting data request information from the selected first remote to the central unit simultaneously with the data transmission request signal over a plurality of the discrete sub-channels that are not in use; and

allocating at least one sub-channel to the selected first remote unit in response to the data request information for facilitating upstream communications between the first remote unit and the central unit.

41. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, a method of informing the central unit of the transmission requirements of a remote unit, the method comprising the steps of:

transmitting a data transmission request from a selected first remote to the central unit, wherein the data transmission request indicates whether a particular data rate is requested or whether a designated amount of information is desired to be transmitted;

allocating at least one sub-channel to the selected first remote unit in response to the data transmission request for facilitating upstream communications between the first

remote unit and the central unit, wherein when a particular data rate is requested, the central unit allocates sufficient sub-channels to the selected first remote unit such that the selected first remote unit can transmit at the requested data rate and wherein the designated amount of information is desired to be transmitted, the central unit allocates the at least one sub-channel to the selected first remote unit for an amount of time sufficient to transmit the designated amount information.

42. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a symbol-based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, a method of informing the central unit of the transmission requirements of a remote unit, the method comprising the steps of:

transmitting, using a fast access transmission mode, a communication access request from a selected first remote unit to the central unit, the communication access request comprising a unique remote unit identifier identifying the selected first remote unit and being transmitted from the selected first remote unit on at least one unused sub-channel using a modulation scheme that does not require equalization to decode at the central unit; and

allocating at least one sub-channel to the selected first remote unit in response to the communication access request for facilitating upstream communications between the selected first remote unit and the central unit.

43. The method of claim 42 wherein:

said communication access request further comprises a data transmission request signal; and

the data transmission request is a defined data packet request signal, and wherein the central unit allocates sufficient sub-channels to the selected first remote unit such that the selected first remote unit can transmit a data packet in conformance with stored defined data packet transmission requirements associated with the selected first remote unit, the stored defined data packet transmission requirements being known to the central unit prior to the receipt of the defined data packet request signal.

44. The method of claim 42 or 43 further comprising the steps of:

inhibiting remote units from transmitting using the fast access transmission mode responsive to a command from the central unit, wherein the command from the central unit is generated when usage on the system exceeds a predefined threshold; and

enabling remote units to transmit using a polled transmission mode responsive to the command from the central unit.

45. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a symbol-based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, an apparatus for transmitting data from a selected remote unit to the central unit, comprising:

a serial to parallel converter for receiving said data and converting said data to parallel data;

an encoder coupled to said serial to parallel converter for encoding said parallel data according to one of a first and a second modulation schemes responsive to a control signal, said first modulation scheme being operative during a polled transmission mode and requires a receiver at said central unit to have prior knowledge of the identity of said selected remote unit for decoding, said second modulation scheme being operative during a fast access transmission mode and does not require the receiver at said central unit to have prior knowledge of the identity of said selected remote unit for decoding;

an IFFT modulator coupled to said encoder for modulating encoded data from said encoder; and

a parallel to serial converter coupled to said IFFT modulator for converting modulated data from said IFFT modulator to a serial format for transmission to said central unit.

46. The apparatus of claim 45 wherein said first modulation scheme is QAM and said second modulation scheme is DQPSK.

47. The apparatus of claim 45 or 46 wherein said polled transmission mode is operative when system usage exceeds a predefined usage threshold and said fast access transmission mode is operative when system usage falls below said predefined usage threshold.

48. The apparatus of claim 47 wherein:

said selected remote unit only sends data on an unallocated sub-channel during a specific symbol period when said polled transmission mode is operative, said specific symbol period being specifically assigned to said selected remote unit for access request; and

said selected remote unit sends data on an unallocated sub-channel during any symbol period when said fast access transmission mode is operative irrespective whether said specific symbol period has been assigned to said selected remote unit for access request.

49. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a symbol-based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central unit, an apparatus for receiving data sent from a selected remote unit to the central unit, comprising:

a serial to parallel converter for receiving said data and converting said forward error corrected data to parallel data;

a FFT demodulator coupled to said serial to parallel converter for demodulating parallel data from said serial to parallel converter;

a decoder coupled to said FFT demodulator for decoding demodulated data from said FFT demodulator according to one of a first and a second demodulation schemes responsive to a control signal, said first demodulation scheme being operative during a polled transmission mode and requires prior knowledge of the identity of said selected remote unit for decoding, said second demodulation scheme being operative during a fast access transmission mode and does not require prior knowledge of the identity of said selected remote unit for decoding; and

a parallel to serial converter coupled to said decoder for converting decoded data from said decoder to a serial format.

50. A method as recited in any one of claims 1-5 and 11-44 wherein the bi-directional data transmission system is an Asymmetric Digital Subscriber Line system that includes the transmission of signals over twisted pair telephone lines and wherein the modulator modulates the encoded digital information onto subcarriers that correspond to subchannels that each have a bandwidth that is approximately 4.3125 kHz wide.

51. A method as recited in any one of claims 1-5 and 11-44 wherein the bi-directional data transmission system is a cable system that includes the transmission of signals over a coaxial cable.

52. A method as recited in any one of claims 1-5 and 11-44 wherein the bi-directional data transmission system is a digital cellular television system that includes the transmission of radio signals.

53. In a bi-directional data transmission system that facilitates communications between a plurality of remote units and a central unit using a frame based discrete multi-carrier transmission scheme that has a multiplicity of discrete sub-channels provided for facilitating upstream communications between the plurality of remote units and the central

unit and downstream communications between the central unit and the plurality of remotes, a method transmitting data comprising the steps of:

a) transmitting at least one frame of downstream data from the central unit to at least one of the remote units using a discrete multi-tone modulation scheme, wherein no upstream data transmissions are permitted during the transmission of the downstream data;

b) transmitting at least one frame of upstream data from at least one of the remote units to the central unit using a discrete multi-tone modulation scheme, wherein no downstream data transmissions are permitted during the transmission of the upstream data; and

c) sequentially repeating steps (a) and (b).

54) A method as recited in claim 53 further comprising the step of providing a settling period after the transmission of at least one of the downstream frames and the upstream frame, wherein no transmissions are made in either direction during the settling period.

55) A method as recited in claim 53 or 54 wherein the permissible data transmissions rates are at least ten million bits per second.